Review Paper on

CLIMATE CHANGE AND WORLD HERITAGE SITE: SAGARMATHA NATIONAL PARK

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1. Introduction

The Sagarmatha National Park was inscribed on the World Heritage List in July 1979 due to its superlative natural phenomena and areas of exceptional natural beauty and aesthetic importance. The 114,800 ha Park is buffered on its southern border by a 27,500 ha buffer zone created in 2002. The Park area is known by the local people as Khumbu. Khumbu is an exceptional high altitude landscape with dramatic scenery of high Himalayan mountain ranges dominated by Mount Everest (Jomo Langma-Sagarmatha) the World's highest mountain (8,848 m).

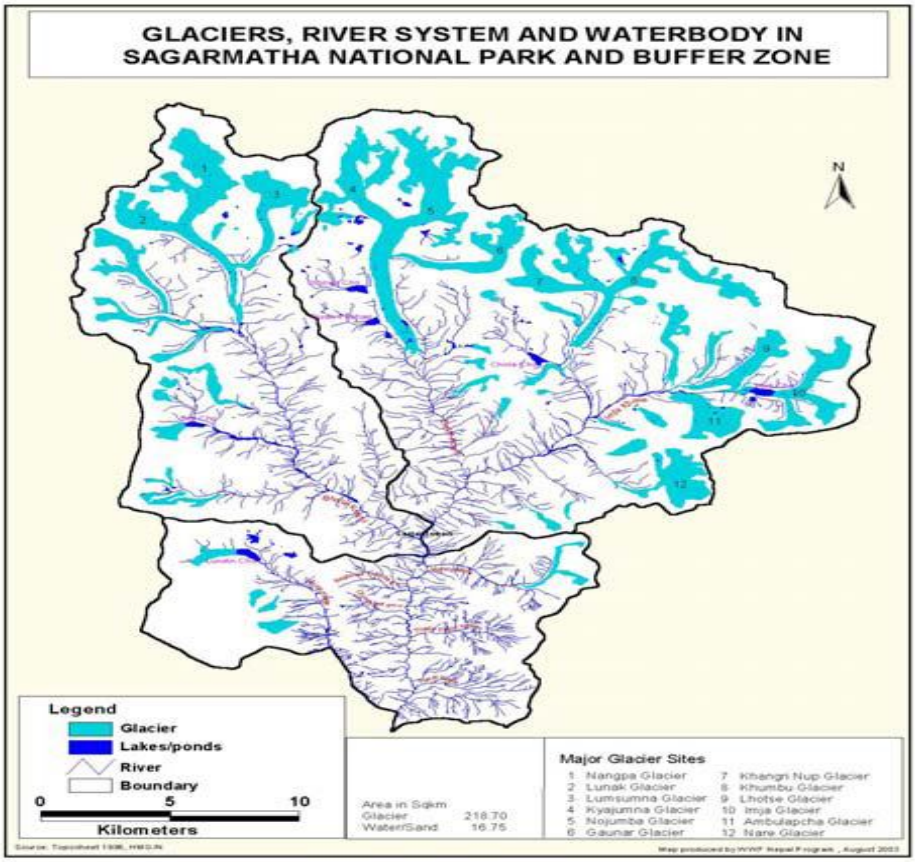

Figure: Glaciers, river system and water body at Sagarmatha National Park

Over 50% of the Park is constituted of high altitude landscape of snow, ice and rock. Besides alpine glaciers, the Park also includes alpine shrubs and deep river valleys covered with sub-alpine vegetation. Several rare species of wildlife such as the snow leopard, the musk deer and the red panda can be encountered in the Sagarmatha National Park. This majestically scenic mountain park of snow-covered peaks, gorges and glaciers dominated by the highest mountain on Earth is geologically interesting and its wilderness values are outstanding. The Dudh Kosi valley is home to the unique culture of the Sherpas and is an ecological unit of biological, socio-economic and religious importance.

The human settlements enclaves are legally considered as the buffer zone of the National Park. But in terms of management, these settlements are an integral part of the Park's overall landscape. There are nearly 6,000 resident people belonging to the Sherpa ethnic group. The presence of the Sherpa People, with their unique cultural traditions, adds further interest to this site. The area began to attract international mountaineers and explorers after Mount Everest was successfully scaled by Sir Edmund P. Hillary and Tenzing Norgay Sherpa in 1953. The Park receives over 20,000 trekkers each year. The key attractions are the scenic beauty of the surrounding mountains, the local culture, and most importantly being close to Mount Everest. Tourism has contributed to improving the livelihoods of the local people. Yet, its impact on the local culture and environment continues to remain a management challenge. The justifications for inclusion of the Sagarmatha National Park on the World Heritage List were geological, biological, aesthetic, and also humanity's interaction with its environment alongside the peculiar evolutionary relationship of the Sherpa People with their own natural environment.

2. Climate Change and its Impacts

Many of the features that constitute the outstanding universal values of the Sagarmatha National Park are the result of, or linked to, past climate variability. Up until the end of the Little Ice Age, snow accumulated in the Sagarmatha National Park, inciting the formation of glaciers. The action of these glaciers contributed to the geological features of the Park, since, as ancient rivers of compressed snow, they crept through and shaped the landscape.

It is now feared that the Himalayan glaciers are rapidly retreating because of climate change. Since the mid-1970s, the average air temperature rose by 1°C in the Himalayan region, i.e. almost twice as fast as the global average warming of 0.6 °C reported by the IPCC, this trend being most pronounced at high altitude sites (Thomas and Rai,2005). And almost 67% of the glaciers in the Himalayan and Tienshan mountain ranges have retreated in the past decade (IPCC, 2001) by as much as 30 m per year for the Gangotri glacier.

Figure: The Pattar Glacier in Sagarmatha National Park

The most visible impact of this trend is related to the aesthetic values of the mountains. Melting of the snow will turn the snow-covered mountains into bare, rocky mountains. The Himalayas will no longer be the 'abode of snow'. The dynamic glaciers will turn into lifeless rubble without their icy core. And in addition to the visual degradation for tourism and culture, the lack of snow will also have unfavourable consequences on the climbing experience. The most devastating impact will concern the hydrological regime. Rapid melting of glaciers is already increasing the magnitude and frequency of catastrophic floods downstream. The continued melting will eventually affect the availability of life-giving water for drinking, food production, and ecosystem maintenance. Changes in the atmospheric temperature and in the rate of rainfall will affect the equilibrium between the amount of precipitation stored in winter and the melt away

during summer. The melting season of snow coincides with the rainy season in the Himalayas. Consequently, any intensification of rainfall is likely to contribute to the rapid disappearance of snow and ice (IPCC, 2001). It is therefore expected that the Himalayan region will gradually lose its ability to serve as water towers for billions of people living downstream of its lofty summits. And scarcity of water will not only impoverish lives but may breed conflicts at the local and regional scale.

2.1 Glacial Lake and Outburst Flood

The melting of glaciers leads to the formation and rapid expansion of glacial lakes whose banks are made of loose glacial debris and unstable remnant ice. Glacial lakes are often located at the base of mountains with hanging ice. While the lake at the base continues to fill up, ice blocks from the mountain slope above detach (usually triggered off by earthquakes) and plunge into the lake, creating waves that break the loose moraine dam, causing a sudden discharge of large volumes of water. Floods of this kind are referred to as Glacial Lake Outburst Floods (GLOF) and have disastrous consequences for the population and for the biodiversity of the entire watershed. GLOFs are a natural phenomenon in the Khumbu region (WHC, 2002) but this threat is exacerbated in the context of climate change.

Within the span of two decades, three major GLOF events were experienced in the Khumbu. A damaging GLOF event in 1977 from the base of Mount Amadablam destroyed park facilities and a tourist lodge located along the riverbeds. A second GLOF in August 1985 from Digchho Lake, completely destroyed the Namche Hydropower Station, trails, bridges, and washed away cultivated land, houses, livestock and killing at least 20 people along its 90 km downstream impact zone. The most recent GLOF in the eastern part of the Sagarmatha National Park occurred on 3 September 1998, in the Hinku Valley. Today, the Imja Lake in Sagarmatha National Park is identified as one of the largest and most threatening lakes needing urgent monitoring and risk assessment and preparedness. In the eastern Himalayan region, in general, more than 15 major GLOF events have been recorded since 1995. Recently, the International Centre for Integrated Mountain Development (ICIMOD), with the support of the United Nations

Environmental Programme (UNEP), released the results of an inventory of glaciers, glacial lakes, and GLOF in Nepal and Bhutan. The study mentioned 3,252 glaciers and 2,323 glacial lakes in Nepal among which twenty were potentially dangerous (ICIMOD, 2002).

2.2 Water Supply

Half of the freshwater used by humankind originates from mountain glaciers. If glacier melting continues at its current pace, the winter snowfall will not be sufficient to replenish the amount of snow and ice lost through melting, leading to a deficit in water storage in the form of snow and ice. This could cause many rivers to run dry, inducing shortages of water for drinking, agricultural irrigation, and affecting fisheries and wildlife. This is confirmed by numerical models which show that, in the context of climate change there will be an increase in river discharge in the short term causing widespread flooding. But in the medium term (a few decades), steady negative trends of water levels of glacial rivers will be observed. The Himalayan region provides freshwater to one third of the world's population (WWF, 2003). By supplying water to the Ganges, Indus, Brahmaputra, Salween, Mekong, Yangtze and Huang He rivers, glaciers in this area ensure a year-round water supply to 2 billion people. In the Ganges alone, the loss of glacier-melt water would reduce July-September flows drastically, impacting livelihoods of 500 million people and of 37% of India's irrigated land (Jain, 2001). In the northern Tienshan Mountains of Kazakhstan, more than 90% of the region's water supply is used for agriculture and up to 80% of river runoff is derived from glaciers and permafrost, which are melting at accelerated rates.

2.3 Biodiversity, Geology, and Cultural Aspects

Climate change affects vegetation in a major way, for example with tree-line shifts towards higher elevation as a response to increased temperature. In that process, least-adapted vegetation and animal species may be squeezed out, and eventually disappear, because plants and animal populations respond to changing climates individualistically. Consequently, forest communities may not move upslope intact because some species will adapt and expand, while others will

perish. Changes in disturbance regimes must also be taken into account. Assuming that the projected warming will be accompanied by sufficient moisture availability, the vegetative cover in the Sagarmatha National Park could increase, because currently the limiting factor for plant growth is the low temperature. But if the moisture does not increase, the warming trend may cause more forest fires. Also, increased temperature will affect the incidence of invasive species, including pests and diseases.

Despite these changes in the environment, people will continue to reside in the Park and the interaction of the human race with nature will continue. The Little Ice Age cooling maintained humanity's well-being to a minimum. The warming may bring the reverse effect. Population growth, settlement expansion and encroachment are likely to become a major management challenge. And the integrity of the indigenous Sherpa People's culture will erode further under growing external influences. Nevertheless, some of the outstanding universal values such as the wonderful geological formation of the Park and status of Mount Everest as the highest mountain in the world would not be affected, even if its scenic and cultural values would diminish due to lack of snow covered protection.

2.4 Additional Sources of Stress

World Heritage sites, such as the Sagarmatha National Park, are fragile properties. Climate change is a serious external threat to the long-term conservation of their values. But this threat must be considered as one of many issues. The Park is also vulnerable to a series of locally triggered pressures, and requires active management solutions at the local level. In a whole there is the presence of generally two types of pressure that is playing as an active cause to undermine the importance of world heritage and especially Sagarmatha National Park.

- **Resource pressure:** The number of trekkers and mountaineers visiting the Park continues to remain high. And the population of Sagarmatha National Park is growing steadily. The movement of economic migrants into the Park has increased significantly, although the growth is somewhat offset by the out-migration of local residents. So the high economic

activity and the arrival of tourists, SNP is feeling the heat of crowded space and over burden due to resource.

- **Development pressure:** As the Park continues to attract large numbers of trekkers and climbers the pressure in terms of development of tourism infrastructure is increasing. The construction of houses, hotels, pavements etc. inside the premises of SNP attribute to development pressure. So it directly affects the tranquility of the national park and as a whole to its uniqueness. Day by day concretes are added which demolishes its true beauty. SNP is revered for its exceptionality from rest of the protected areas. So timely intervention is needed to preserve its exquisiteness.

3. Possible Responses

In terms of possible responses, the solution to the problem of global warming lies beyond the boundary of the Sagarmatha National Park. The Park however provides an ideal laboratory for studying the impact of global warming and some research, information, and mitigation measures could be integrated into management plans and implemented to avoid further damage to ecosystems and people.

- **Monitoring and early warning:** An effective monitoring and early warning system embedded in an appropriate risk preparedness strategy can greatly reduce the loss of lives and properties induced by GLOF events downstream of potentially dangerous glacial lakes. Appropriate measures include the use of remote-sensing tools such as the Land Observation Satellite (LANDSAT), over-flight reconnaissance with small format cameras, telecommunication and radio broadcasting system integrated with on-site installed hydro-meteorological and geophysical instruments. In this regard, the methods of the World Glacier Monitoring Service provide state-of the-art guidance for efficient monitoring of the state of conservation of glaciers.
- **Adaptation:** In many instances, immediate disaster may also be averted, by artificially draining potentially dangerous glacial lakes to avoid such outbursts of flooding. Such a measure is being implemented on the Tsho Rolpa Lake in the Rolwaling Valley in the western part of the Sagarmatha National Park. Research in various fields has been

undertaken for many years and the Park may prove an excellent site to study the changing climate and ways to control the hazard of outburst floods as was done in 2002 for the Tsho Rolpa lake in the western range (UNESCO/WHC, 2007). The possible strategies available to prevent a glacial lake outburst flood are: (i) Controlled breaching; (ii) Construction of an outlet control structure; (iii) Pumping or siphoning out the water from the lake; (iv) Tunneling through the moraine wall to, or under, an ice dam to release water; (v) Dam construction; and (vi) Reducing the risk of avalanches into the lake.

The Tsho Rolpa GLOF management project was conducted between 1998 and 2002 (Agrawal, 2003). The lake was storing approximately 90 to 100 million m^3 held by a 150 m tall moraine. A breach in this moraine would have caused at least a third of the lake to flood the valley. This threat led to a collaborative action by the Government of Nepal and the Netherlands Development Agency (NDA), jointly with the technical assistance of Reynolds Geo- Sciences Ltd., supported by the Department for International Development (DFID), United Kingdom. The project consisted in draining the lake and lowering its level by 3 m and installing early warning systems in villages downstream. The Project was completed in December 2002, leading to GLOF risk reduction by 20% but complete prevention of such an event would require further draining, perhaps as much as 17 m. The cost would, of course, be high but much less than the cost of damages caused to the infrastructures, biodiversity, and most importantly the loss of lives from an uncontrolled GLOF.

4. Conclusion

The climate of our planet is changing. The climate has always been variable, but today there is a growing concern over climate change issues, perhaps because the magnitude of the change seems to be unprecedented but, more importantly, because there is strong evidence to suggest that humanity might be directly responsible for climate change. Climate change is now considered as one of the major environmental challenges of the Twenty-first Century. Current observed changes or threats on this World Heritage site relate more to direct interference of humanity than

to climate change. However, there are already several indications that changes in the climate tending towards more aridity are taking place and may threaten the conservation of this nature's paradise. The convention concerning the protection of World Cultural and Natural Heritage adopted by UNESCO in 1972 aims at ensuring that outstanding sites around the globe are effectively preserved and passed onto future generation. But this task becomes very difficult in a situation where, because of climate change, glaciers are melting; animal and plant species are migrating outside designated protected areas to acclimatize to their changing environment; pest infestation is increasing and other unimaginable events are occurring fast which were never in sight as reported by the local people. So judicious intervention in the effected areas must come thick and fast and other areas which may get caught in this storm should be prepared well.

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